

## VLSI 2012 Final Solution

1. 兩小題, (a)各 2 分, (b)各 3 分, 共 10 分。

(a)

Fig. (a)  $Y = \overline{A \cdot B}$

Fig. (b)  $Y = \overline{\overline{A} + \overline{B}}$

(b)

Fig. (a)  $g_d = 1$  ;  $p_d = \frac{4}{3}$

Fig. (b)  $g_d = \frac{2}{3}$  ;  $p_d = \frac{5}{3}$

2. 每一小題 2.5 分；依正確性酌量扣分。

(a) 請參考講義 5-47

(b) 請參考講義 5-57

(c) 請參考講義 5-59

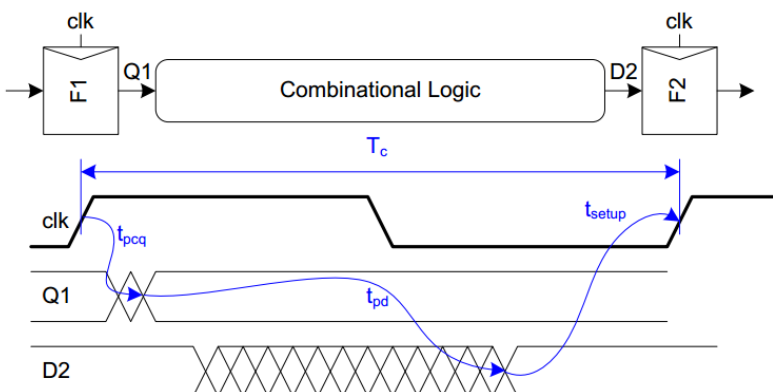
(d) 請參考講義 5-51

3. 五小題, 各 2 分, 共 10 分。

(a)

$$T_{pd} \leq T_c - (T_{setup} + T_{pcq}) = 20\text{ns} - (2\text{ns} + 1.2\text{ns}) = 16.8\text{ns}$$

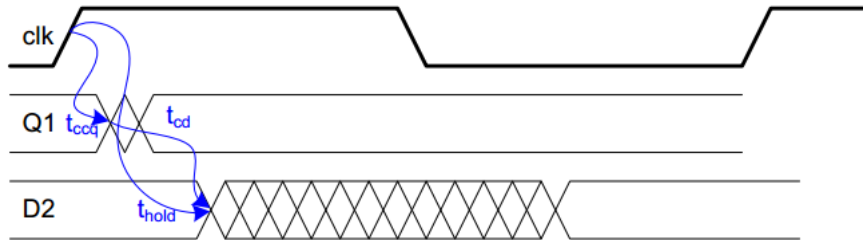
(b)



(c)

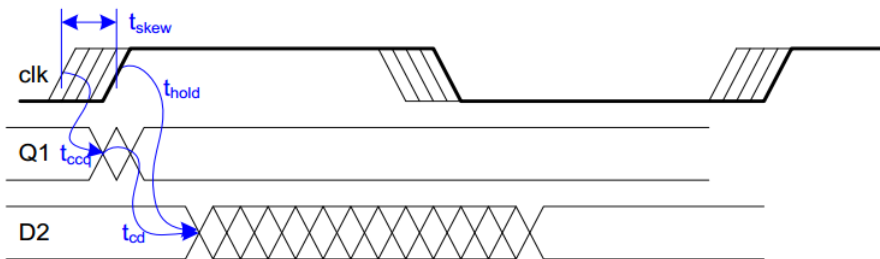
$$T_{cd} \geq T_{hold} - T_{ccq} = 2.8\text{ns} - 0.5\text{ns} = 2.3\text{ns}$$

(d)



(e)

$$T_{cd} \geq T_{hold} - T_{ccq} + T_{skew}$$



4. 只寫 clk and !clk 不給分，要解釋出是什麼現象才有分。

- (a) Race: direct path from D to Q when clk and !clk are both high.
- (b) Undefined : Both B and D are driving A when clk and !clk are both high.
- (c) Dynamic : unknow X when clk and !clk are both low.
- (d) using two phase clk or nonoverlap design.

5. (2.5% each)

$$G=A \cdot B$$

$$P=A \oplus B$$

6. 每一小題 2 分，(a)(b)(c)小題依正確性酌量扣 1 分，(d)小題錯全扣，(e)小題選其中一種架構畫即可，接線錯誤扣 1 分。

(a) 請參考講義 7-32

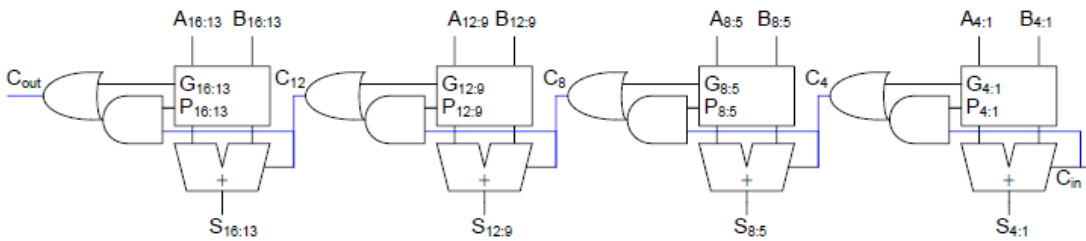
(b) 請參考講義 7-36

(c) 請參考講義 7-28

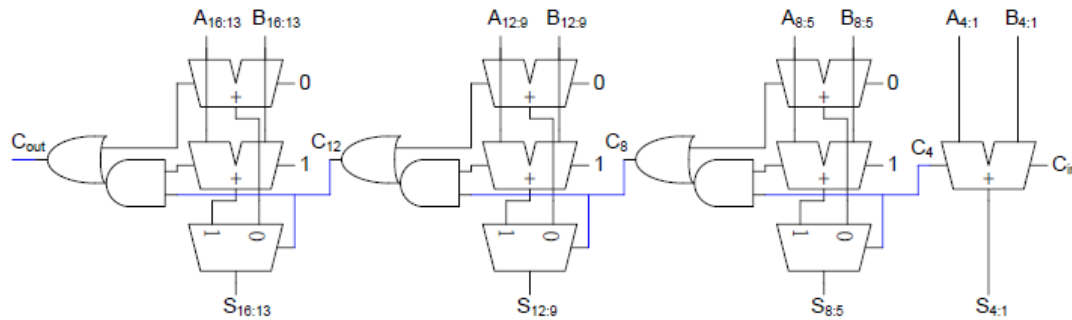
(d) fast to slow: Carry-Select > Carry-Lookahead > Carry-Skip

(e) Pick one type to sketch

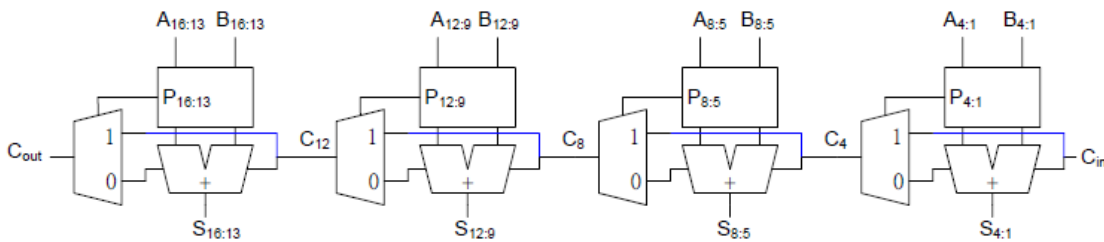
Carry-Lookahead:



Carry-Select:

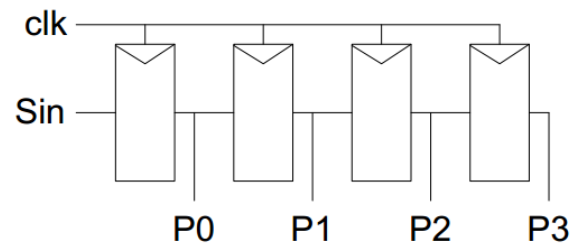


Carry-Skip:

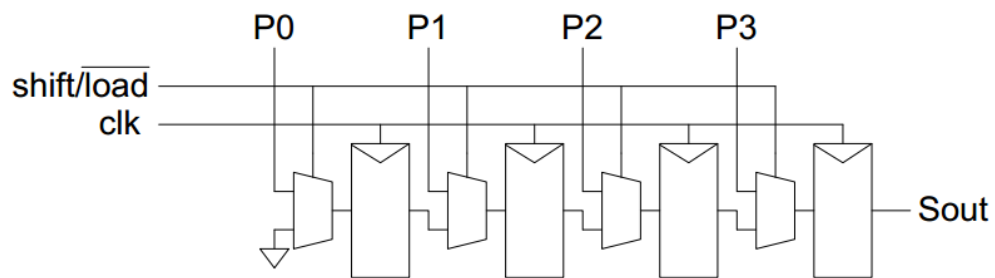


7. (2.5% each)

(A)



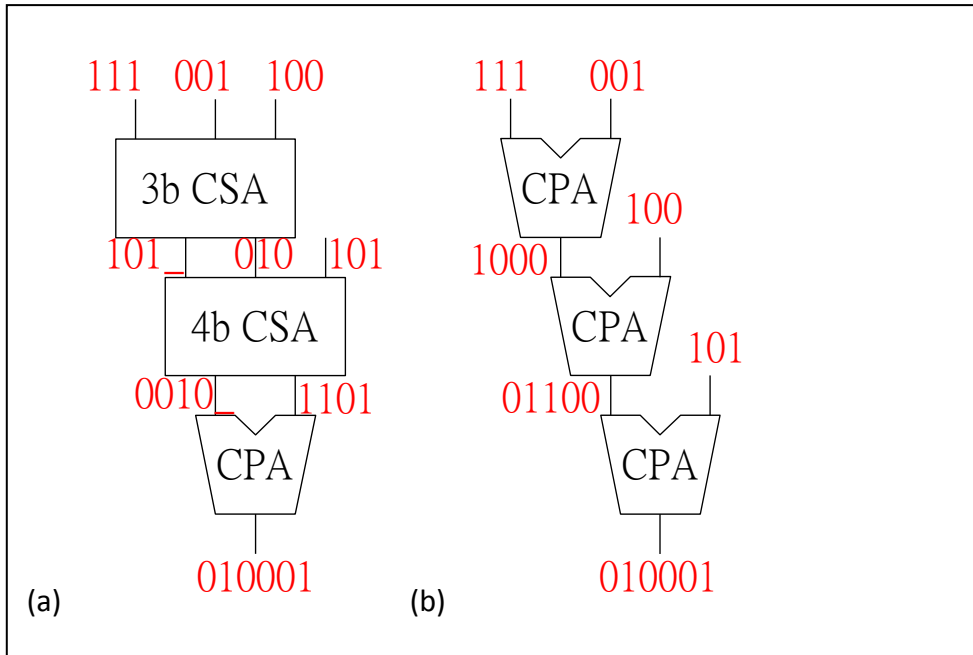
(B)



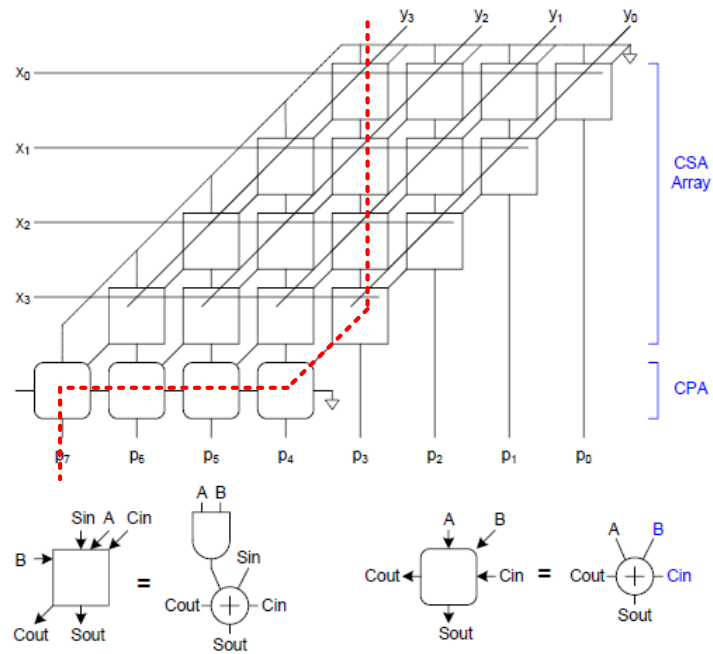
8. 兩小題, 各 2.5 分, 共 5 分, 依解釋的正確性酌量給分。

- **Open bitlines**: use another subarray as reference
  - Higher density
  - Noise affect one array more than the other appears as differential noise.
- **Folded bitlines**: take the neighbor cell in the same subarray as reference
  - Noise appears as common mode
  - Larger layout area

9. 有畫對圖給一半，運算值給另一半。

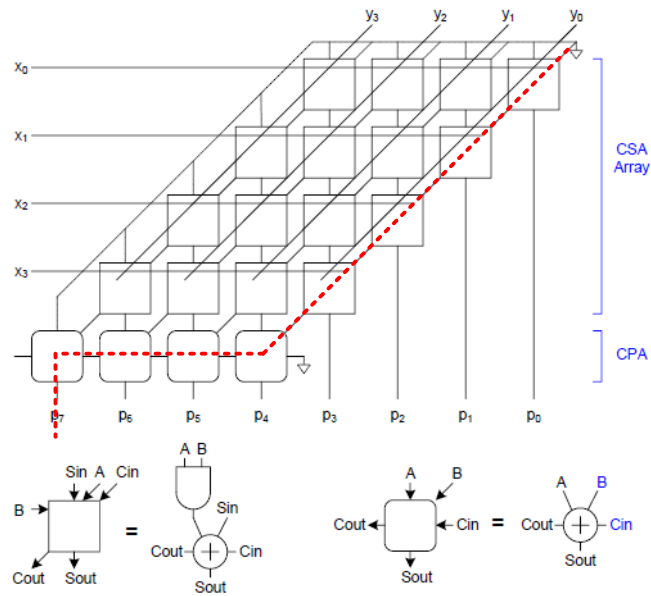


10. (2.5% each)



(A)

$$3(S_{in-to-S_{out}})_{CSA} + (S_{in-to-C_{out}})_{CSA} + (S_{in-to-C_{out}})_{CPA} + 2(C_{in-to-C_{out}})_{CPA} + (C_{in-to-S_{out}})_{CPA} = 3 \times 4 + 6 \times 4 = 36$$



$$1(S_{in}-t_0-C_{out})_{CSA}+3(C_{in}-t_0-C_{out})_{CSA}+(S_{in}-t_0-C_{out})_{CPA}+2(C_{in}-t_0-C_{out})_{CPA}+(C_{in}-t_0-S_{out})_{CPA}=2 \times 4+6 \times 4=32$$

**11. (a) 沒單位不給分**

- (a) low  $\rightarrow 0.5 \times 600 / (200 + 600) = 3/8 = 0.375V$   
 high  $\rightarrow (1 \times 200 + 0.5 \times 600) / (200 + 600) = 5/8 = 0.625V$
- (b) double VDD, double cell capacitance

**12. 每一小題 2.5 分，依解釋的正確性酌量扣分。**

(a)

Read disturb:

Assume  $Q=0$ , during the read operation:

- $\therefore$  BL is precharged at VDD
- $\therefore$  Q will rise due to voltage division

Q must not flip,  $\left(\frac{W}{L}\right)_{PD} > \left(\frac{W}{L}\right)_{PG}$

(b)

Write:

寫入”0”時，pass-gate NMOS，要和 pull-up PMOS 競爭，PG 需較強，假設 mobility 一樣，

$$\left(\frac{W}{L}\right)_{PG} > \left(\frac{W}{L}\right)_{PU}$$

**13.** 有寫到關鍵字就給分。

- (a) to precharge both bitline and bitline\_b to high
- (b) to select column or reduce column circuits area.
- (c) ECC, redundancy, BIST
- (d) Mask ROM, PROM, EPROM, EEPROM, Flash
- (e) to find the memory location of data match

**14.** 兩小題, 各 2.5 分, 共 5 分。

(a)

$$D = Nf^{\frac{1}{N}} + N = N\left(\frac{512}{4}\right)^{\frac{1}{N}} + N = N(128)^{\frac{1}{N}} + N$$

N	1	2	3	4	5	6	7
D	129	24.6	18.1	17.5	18.2	19.5	21

Ans : N=4

(b)

$$f_i = \sqrt[4]{128} = 3.36$$

$$D = 17.5$$

**15.** (2.5% each)

(A)

$$1k \times 40fF + \left(1k + \frac{0.2\Omega}{\mu m} \times 2000\mu m\right) \times \left(\frac{0.8fF}{\mu m} \times 2000\mu m + 2\left(\frac{0.4fF}{\mu m} \times 2000\mu m\right)\right)$$

$$= 4.52 \times 10^{-9} \text{sec} = 4.52 \text{ns}$$

(B)

$$\frac{-\left(\frac{0.4fF}{\mu m} \times 2000\mu m\right)}{\left(\frac{0.4fF}{\mu m} \times 2000\mu m\right) + \left(\frac{0.8fF}{\mu m} \times 2000\mu m\right)} = \frac{-1}{3} = -0.3333333V$$

16. 每一小題 2.5 分；A 小題錯全錯，B 小題錯一個扣一分，扣完為止。

(a)

$$F = GBH = \left(1 \times \frac{5}{3} \times \frac{5}{3} \times 1\right) (2 \times 2) \left(\frac{128}{2}\right) = \frac{6400}{9}$$

$$N = 4, \quad P = 1 + 3 + 2 + 1 = 7$$

$$D = NF^{\frac{1}{N}} + P = 27.656$$

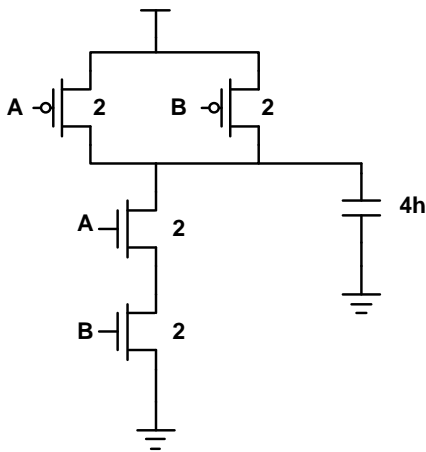
(b)

$$f = \left(\frac{6400}{9}\right)^{\frac{1}{4}} = 5.164$$

$$C_{in} = \frac{g \times C_{out}}{f}$$

$$\Rightarrow \begin{cases} z = \frac{1 \times 128}{5.164} = 24.787 \\ y = \frac{5/3 \times 24.787}{5.164} = 7.9999 \\ x = \frac{5/3 \times 7.9999 \times 2}{5.164} = 5.164 \end{cases}$$

17. (2.5% each)



(A)

$$t_{pdf} = (6 + 4h)RC + 2C \times \frac{R}{2} = (7 + 4h)RC = (7 + 4h)\tau = (7 + 4h) \frac{inv}{3}$$

$$t_{pdr} = (6 + 4h)RC$$

$$t_{pd} = \frac{(t_{pdf} + t_{pdr})}{2} = (6.5 + 4h)RC$$



(B)

$$t_{cdf} = (6 + 4h)RC$$

$$t_{cdr} = (6 + 4h)C \times \frac{R}{2}$$

$$t_{cd} = \frac{(t_{cdf} + t_{cdr})}{2} = (4.5 + 3h)RC$$

**18.** (1% each)

T,T,F,F,T,T,T,T,T